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# Review on renewable energy-based KY boost converter and seven level-inverter systems

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ABSTRACT

Static VAR compensators (SVC), power rectifiers, and thyristor converters are examples of power electronics components that significantly contribute to harmonics in a range of applications. The use of power electronic converters, especially DC/AC PWM inverters, has been expanding in the industry due to the advantages they provide, including reduced energy consumption, improved system efficiency, higher-quality products, simplicity of maintenance, and more. One of the most basic and well-known topologies for multilevel inverters is cascaded H-Bridge (CHB) MLI. A KY boost converter with seven-level inverters is suggested in this study. A Matlab simulation is used to evaluate the suggested work. According to the simulation findings, the output voltage climbed from 121V to 155V, the motor speed increased from 940 rpm to 1050 rpm, the motor torque increased from 0.92 N/m to 1.80 N/m, and the output current THD decreased from 31.2% to 19.01% when a KY boost converter with a seven-level inverter was used. According to the simulation results, the conventional boost converter with a five-level inverter system performs worse than the suggested KY boost converter with seven-level inverters.

**Keywords:** KY boost converter; Multilevel inverter; Solar PV; Pulse width modulation; Motor load.

## 1. Introduction

Directly connecting a single power semiconductor switch to a medium voltage grid is tricky [1-3]. For high-power and medium-voltage applications such as laminators, mills, conveyors, pumps, fans, blowers, compressors, and so on, a multilevel power converter structure has been suggested as a solution. In addition to achieving high power ratings, multilevel converters are a cost-effective option that makes it simple to link low-power applications—like fuel cells, wind, and photovoltaic systems—to a multilevel converter system for a high-power use [4-6]. As was already noted, inverters in these application areas must be able to handle enormous power and high voltage. Integrated gate commutated transistors (IGCTs), integrated gate bipolar transistors (IGBTs), and gate-turn-off thyristors (GTOs) are examples of switching power devices that have been connected in series to create two-level high-voltage and large-power inverters because the series connection allows for much higher voltages. Switching power devices coupled in series, however, provide serious problems [7]. Among these problems is the uneven distribution of applied device voltage. In both transient and steady-state switching processes, the applied voltage of devices coupled in series can cause a single device to be substantially higher than the voltage required to block the device. The output voltage of the multilayer inverter is made up of several levels that are synthesised from different DC voltage sources; as the number of voltage levels increases, the output voltage's quality improves, allowing for a reduction in the number of filters.

### 1.1. Study Objectives

This work's primary contribution is: (1) Simulation of boost converters for the integration of a 5-level inverter system and renewable energy sources, (2) To model K-Y Boost converters in order to integrate a seven-level inverter system and renewable energy sources, and (3) In order to integrate renewable energy sources with a seven-level inverter PR controlled system, closed loop K-Y Boost converters are simulated.

## 2. Literature review

The three-level converter is where the term "multilevel" was initially introduced. There are presently numerous multilayer converter topologies available [8,9]. In 1981, the diode-clamped multilevel inverter approach, sometimes referred to as the Neutral-Point Clamped (NPC) inverter system, was proposed [10]. Cascade inverters are also used in applications that use regenerative motor drives [11,12]. Recently, some new multilayer inverter topologies have emerged. These include generalised multilevel inverters [13], hybrid multilevel inverters [15,16], mixed multilevel inverters [14], and soft-switched multilevel inverters [17].

By adding more voltage levels, these multilayer inverters can increase the suggested inverter voltage and power. They can also increase the equivalent switching frequency without increasing the actual switching frequency, which reduces the ripple component of the inverter output voltage and the impacts of electromagnetic interference. The multilayer voltage source inverter can generate high voltages and power levels without the usage of transformers due to its unique design [18]. They are particularly well suited for high-voltage vehicle drives when total harmonic distortion (THD) and electromagnetic interference (EMI) are required. Combining different DC voltage levels to produce the desired voltage is the primary function of the multilevel inverter. This makes it easy for several inverters to provide the high power required for a large EV or HEV vehicle. Multilevel PWM has been used in some capacity to control the switching of the rectifier and inverter sections in three-, five-, and seven-level rectifier-inverter drive systems that have been examined in the literature [19,20].

Multilevel PWM has a lower dv/dt ratio than certain two-level PWM drivers since it alternates between several smaller voltage levels. The number of levels and the number of DC sources are strongly connected, according to the steady-state switching operation of devices equation. The output voltage of the multilayer inverter is made up of several levels that are combined from different DC voltage sources. Because the quality of the output voltage increases with the number of voltage levels, fewer output filters are needed.

$$n = m - 1 \qquad \ldots(1)$$

where ‘n’ is the number of dc supplies connected in series and ‘m’ is the number of the output voltage levels.

In a cascaded H-Bridge (CHB) architecture, m= 2N+1, where N is the number of DC sources, provides the number of output-phase voltage levels. A seven-level cascaded converter, for example, consists of three DC sources and three full bridge converters. By varying the conducting angles at different stages of the converter, the least amount of harmonic distortion can be achieved. To create a quasi-square waveform, each H-bridge unit phase shifts the switching timings of its positive and negative phase legs. Any switching device, regardless of the pulse width of the quasi-square wave, conducts for 180° (or half cycle).

## 3. Proposed System

Figure 1 displays the simulation block diagram of the suggested KY Boost Converter System with 7-Level Inverter for an open loop system.

• A 7-Level Inverter is used to convert the PV output to AC.

• A pulse generator is used to create the pulses for the KY-Boost Converter and the 7-Level Inverter.

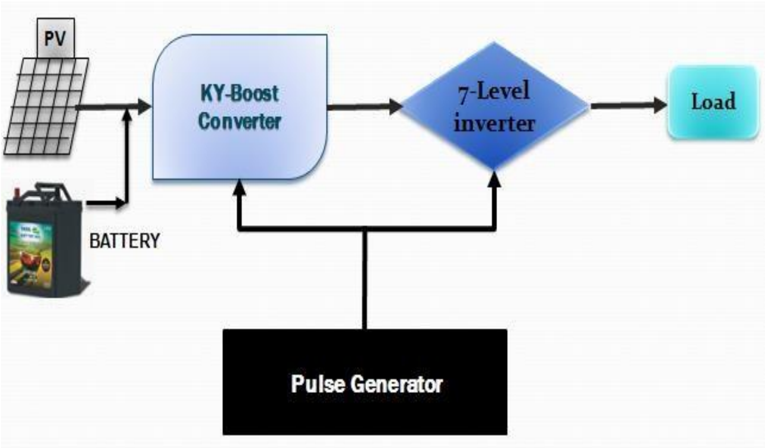


**Figure 1.** Proposed open loop Simulation block diagram

Figure 2 displays the simulation block diagram of the suggested KY Boost Converter System with a 7-Level Inverter for a closed loop system.

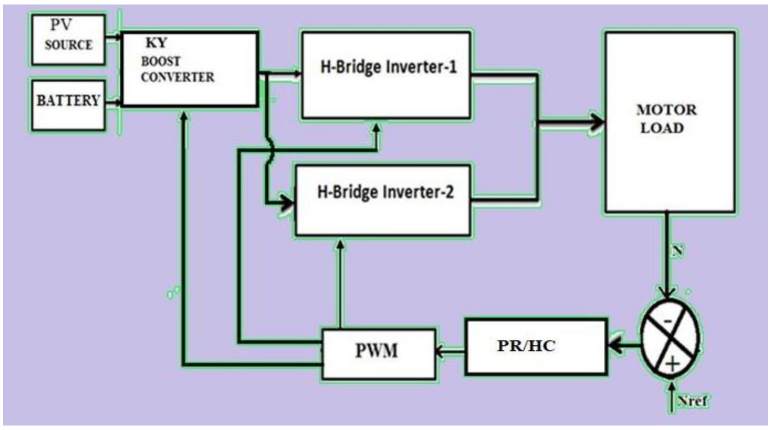


**Figure 2.** Proposed closed loop Simulation block diagram

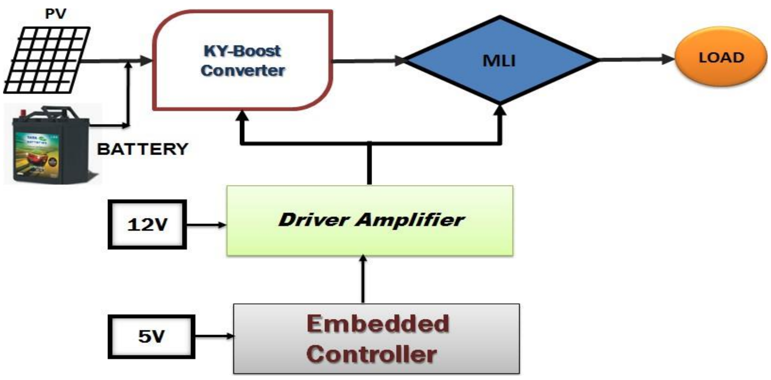


**Figure 3.** Hardware block diagram

The hardware Block Diagram of Proposed KY Boost Converter System is shown in Figure 3.

- Output of PV1 is boosted using KY-boost converter 1.
- Output of PV2 is boosted using KY-boost converter 2.
- Outputs of H-bridges-1 and 2 are cascaded to get Multi level output.
- Pulses from PIC are amplified using driver.

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## 4. Results and Discussion

### 4.1. 7-level inverter with motor-load

Circuit diagram of KY boost converter and 7-level inverter with motor-load is shown in Figure 4.

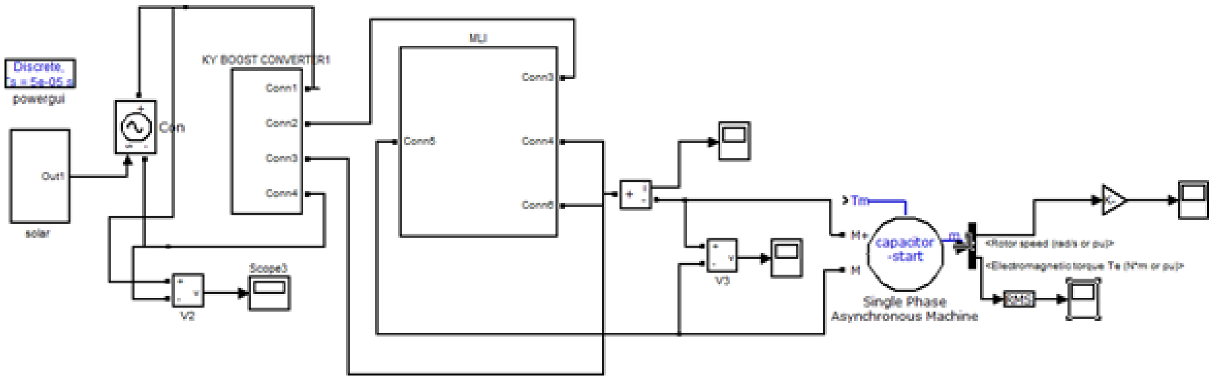


**Figure 4.** Circuit diagram of 7-level inverter with motor-load

The voltage across the PV of a seven-level inverter with a motor load is displayed in Figure 5. The voltage is 48 volts. Figure 6 shows the circuit diagram for the KY boost converter. As illustrated in Figure 7, the switching pulse value for the KY boost converter S1 and S2 is 10 volts. As seen in Figure 8, the voltage across the KY boost converter is 155 volts. The circuit schematic for the 7-level inverter is shown in Figure 9. The switching pulse for inverters M1, M2, and M3 with a value of 1 volt is shown in Figure 10. As illustrated in Figure 11, the voltage across the motor-load is 155 volts. The output current via the motor-load, 10 amp, is shown in Figure 12. The output current THD, 19.01%, is displayed in Figure 13. The motor speed of the 7-level inverter with a motor load is shown in Figure 14. It is worth 1050 rpm. The motor torque of a seven-level inverter with a motor load is shown in Figure 15. The torque of the motor is 1.80 N-m. A comparison of output current THD is shown in Table 1. The simulation parameters are represented accordingly.

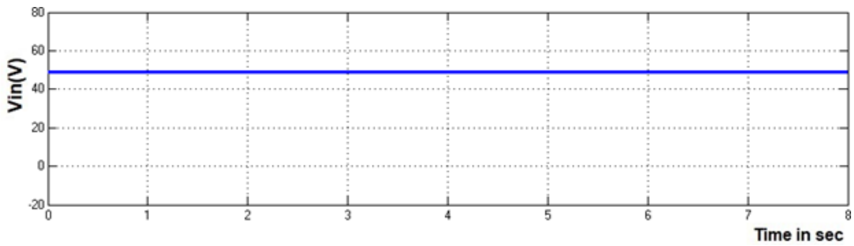


**Figure 5.** Voltage across PV

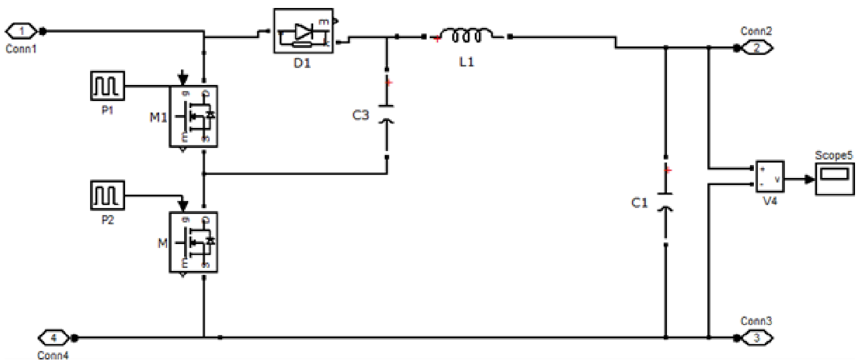


**Figure 6.** Circuit diagram of KY boost converter

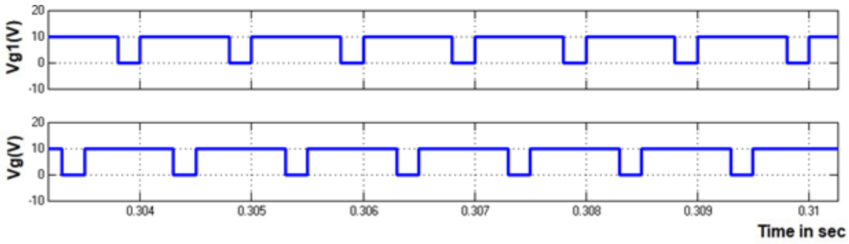


**Figure 7.** Switching pulse for KY boost converter S1and S2

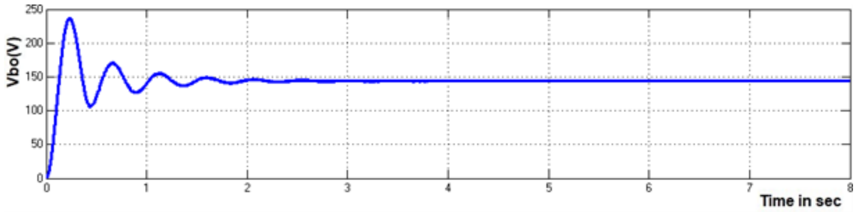


**Figure 8.** Voltage across KY-boost converter

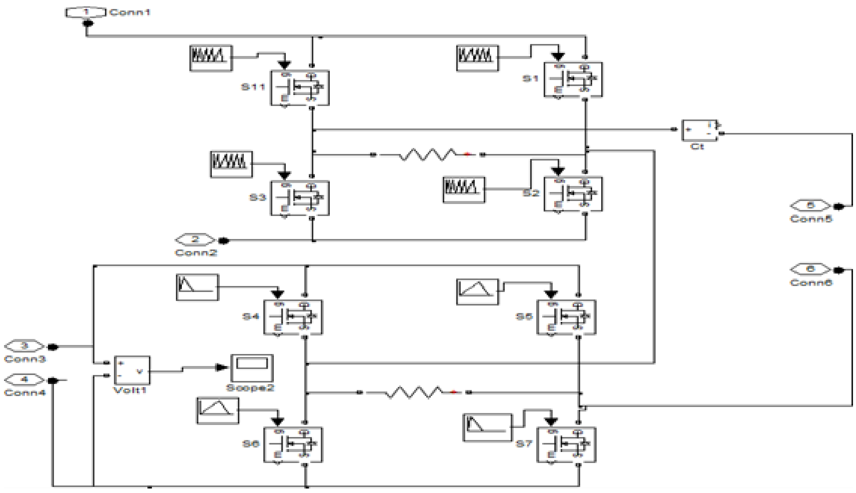


**Figure 9.** Circuit diagram of 7-level inverter

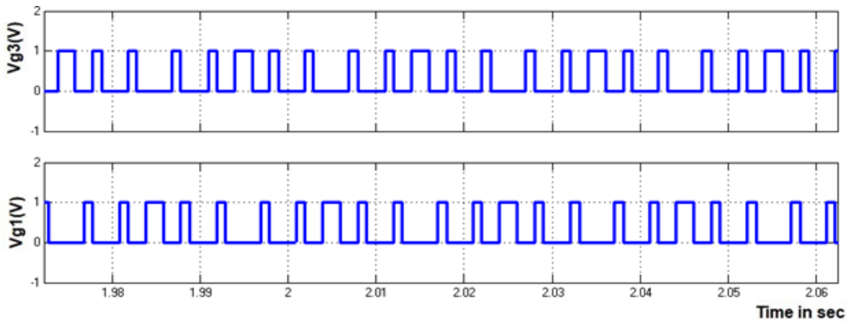


**Figure 10.** Switching pulse for inverter M1, M3

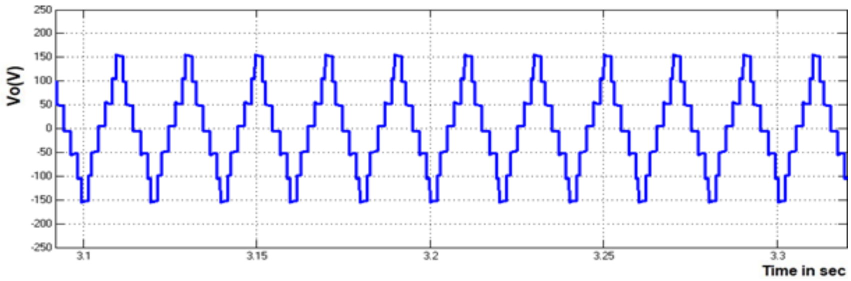


**Figure 11.** Voltage across motor-load

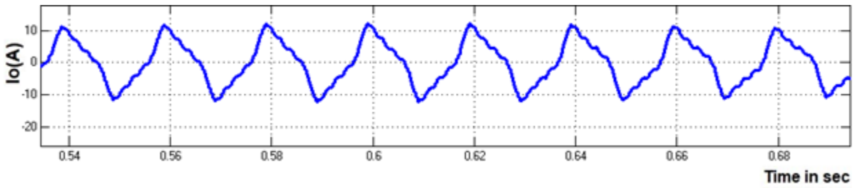


**Figure 12.** Output current through motor-load

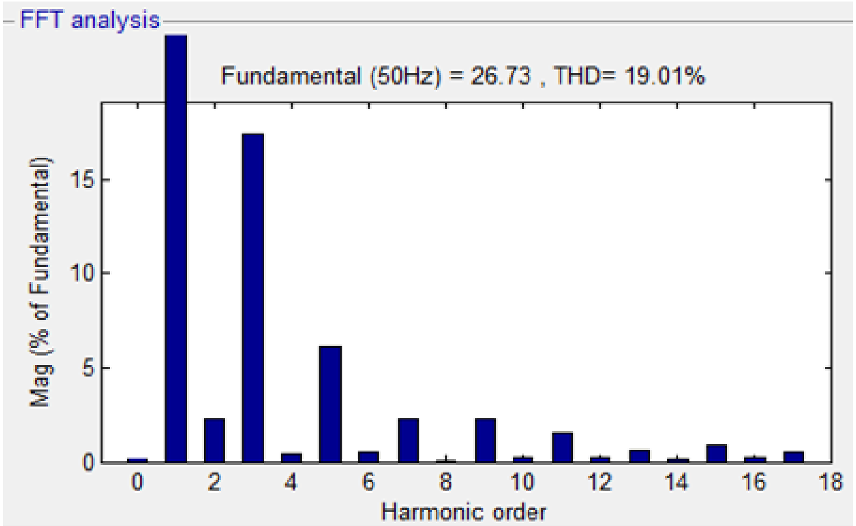


**Figure 13.** Output current THD

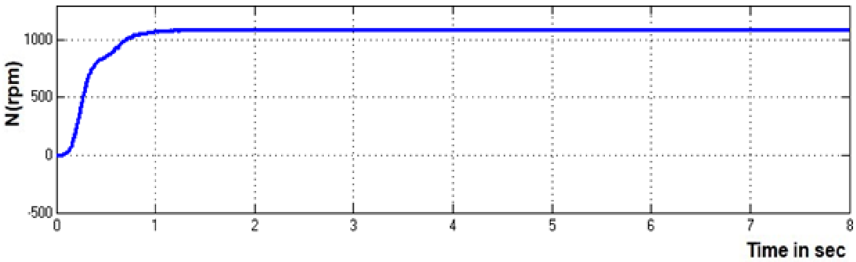


**Figure 14.** Motor speed

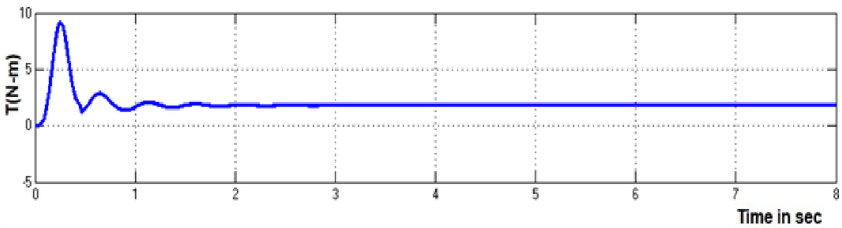


**Figure 15.** Motor Torque

**Table 1.** Comparison of output voltage, motor speed, motor torque and current THD

| MLI | $V_{in}$ (V) | $V_o$ (V) | N (rpm) | T (N-m) | Current THD (%) |
|---|---|---|---|---|---|
| 5-level boost converter with motor load | 48V | 121 | 940 | 0.92 | 31.20 |
| 7-level KY boost converter with motor load | 48V | 155 | 1050 | 1.80 | 19.01 |

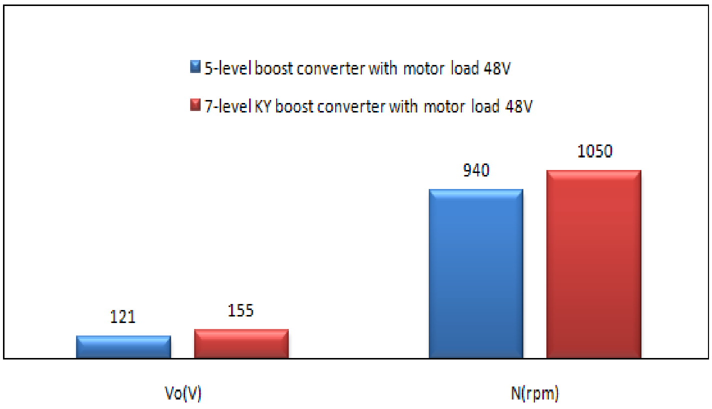


**Figure 16.** Bar chart of motor Torque and current THD

## 5. Conclusion

In this paper, a KY boost converter with seven-level inverters is proposed and modelled. The output voltage increases from 121V to 155V, the motor speed increases from 940 rpm to 1050 rpm, the motor torque increases from 0.92 N-m to 1.80 N-m, and the output current THD decreases from 31.2% to 19.01% when a KY boost converter with seven level inverters is used. According to the simulation results, a traditional boost converter with a five-level inverter system performs worse than the suggested KY boost converter with seven-level inverters.

**Declarations**

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**Competing Interests Statement**

The authors declare no competing financial, professional, or personal interests.

**Consent for publication**

The authors declare that they consented to the publication of this study.

**Authors' contributions**

Both the authors made an equal contribution in the Conception and design of the work, Data collection, Simulation analysis, Drafting the article, and Critical revision of the article. Both the authors have read and approved the final copy of the manuscript.

**Availability of data and material**

Authors are willing to share data and material according to the relevant needs.

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